

# **KING COUNTY CONVEYANCE SYSTEM IMPROVEMENT PROJECT**

## **KENMORE INTERCEPTOR AND NORTH CREEK STORAGE ANALYSIS**

### **MEMORANDUM**

**MARCH 2001**





## **ACKNOWLEDGEMENTS**

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## INTRODUCTION

This memorandum has two primary purposes:

1. To describe potential operational scenarios of the North Creek Storage Facility and associated structures, and
2. To identify the hydraulic limitations of the Kenmore Interceptor/Bothell Woodinville Interceptor under a variety of flow conditions related to operation of the North Creek Storage Facility and the associated diversion structure.

## REVIEW OF EXISTING AND PROPOSED FACILITIES

There are a number of KCWTD conveyance lines and facilities that affect or could be affected by the operation of the North Creek Storage Facility. These facilities include a number of pump stations (Table 1) and major trunks and interceptors (Table 2). Figure 1 shows the location of the KCWTD facilities as well as trunks and interceptors.

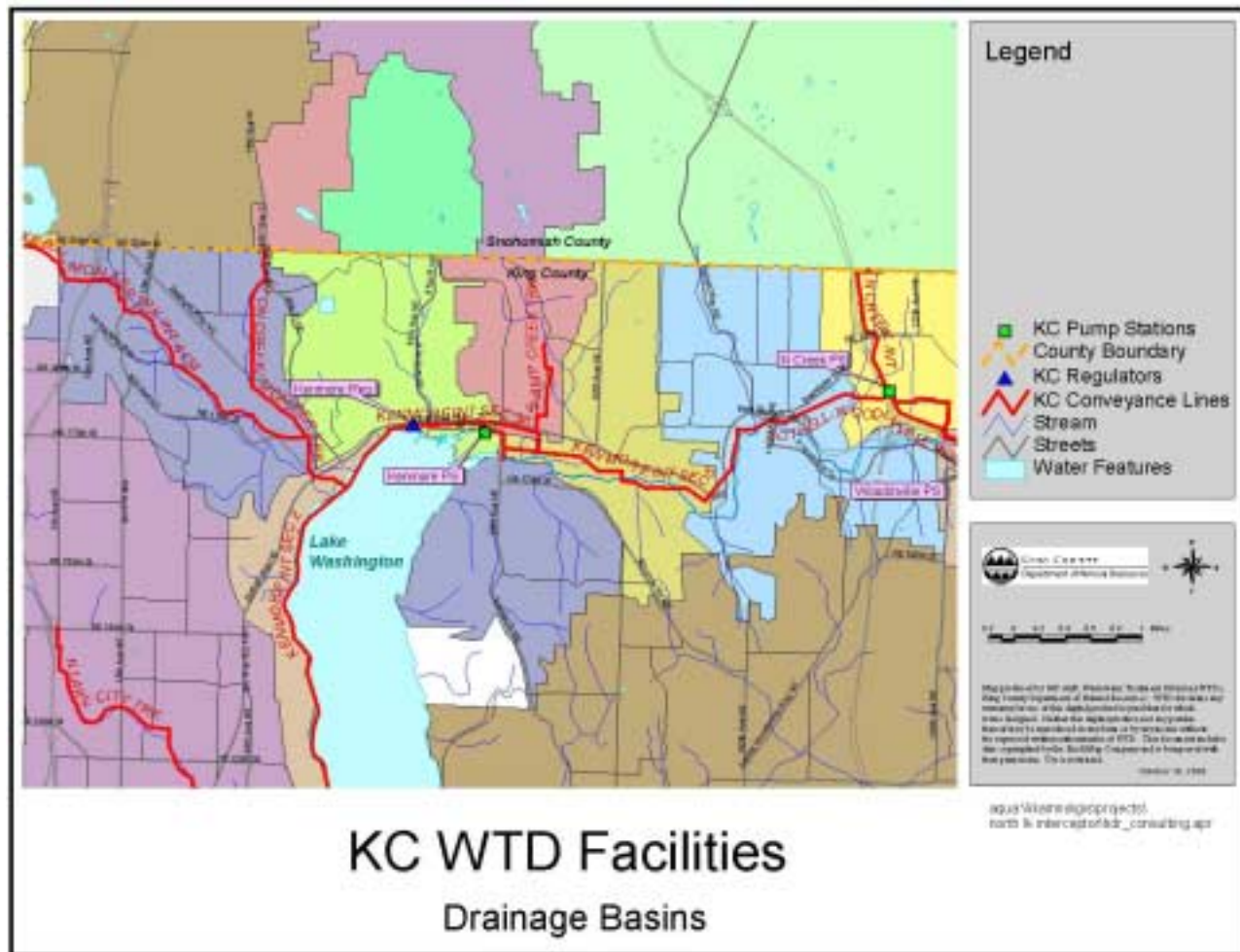
**Table 1. Related King County Pump Stations**

<b>Pump Station</b>	<b>Pump Motors/ Horsepower</b>	<b>Pump TDH (feet)</b>	<b>Firm Capacity (mgd)</b>
Kenmore	2/50 & 2/125	24	18
North Creek	3/500	105	36
Woodinville	3/60	21	18
York	6/600	200	60

**Table 2. Related King County Trunks and Interceptors**

<b>Facility</b>	<b>Length (feet)</b>	<b>Diameter (inches)</b>	<b>Full Pipe Capacity* (mgd)</b>
Inglewood Interceptor	427	27	NA
North Creek Trunk (W11-86 to W85-16)	6,371	42	39-59
Kenmore Interceptor – Section 5 (W11-48 to W11-78)	16,031	60-78	31-151
Bothell-Woodinville Interceptor (W11-78 to W11-86)	4,685	60-84	39-119
Bothell-Woodinville Interceptor (W11-86 to W11-100)	5,257	30-42	12-49

Note: Data from Flowtimes\_North.xls and rounded to the nearest 1 mgd.



**Figure 1. Kenmore Interceptor and Associated KCWTD Facilities.**

The North Creek Storage Facility is currently under design. A workshop was held on October 19, 1999 to help the design team develop the criteria for the proposed facility. Based on input from this meeting, a technical memorandum was prepared by HDR in December 1999 (HDR Memo) that outlined the design and design criteria for this proposed facility. This planning level memorandum was followed by a draft report prepared by Tetra Tech/KCM in August, 2000 and finalized in October, 2000 (KCM Report) that included a more detailed analysis of the hydraulics and potential operation of the proposed North Creek Storage Facility.

One significant recommendation in the KCM Report was to locate the diversion structure downstream of the Bothell Gate. This recommendation is shown on Figure 3-3 from Technical Memorandum No. 3 of the draft predesign report, which is included in Appendix A. This proposed diversion structure location would allow 30 mgd to be diverted from the Bothell-Woodinville Interceptor to the North Creek Storage Facility without exceeding a water surface elevation of 112.5 in the Bothell-Woodinville Interceptor adjacent to the diversion structure. The basis for this maximum water surface elevation is a May 25, 1995 memorandum from KCWTD staff that identified a maximum water surface elevation of 114.08 in Kenmore given a water surface of 112.5 at MH W11-85 and a reverse flow of 29.2 mgd in the Bothell-Woodinville Interceptor. Important



structural elevations related to the North Creek Storage Facility hydraulics are summarized in Table 3.

**Table 3. Significant Hydraulic Elevations**

Structure	Component	Elevation (feet)
Logboom Storage Pipe (South)	Invert (East End)	109.0
Logboom Storage Pipe (South)	Pipe Crown (East End)	120.5
Inglewood Interceptor MH 11-51A	MH Rim	116.5
Kenmore Interceptor MH 11-51	MH Rim	116.8
Kenmore Interceptor MH 11-55	MH Rim	116.8
North Creek Storage Facility – Diversion Structure	Weir – Proposed	111.5
North Creek Pump Station – Diversion Structure	Weir – Bothell Gate	114.5
North Creek Pump Station – Diversion Structure	Invert to Kenmore	108.7
Lake Washington	(Summer Elevation)	114.5

Note: All elevations given with King County Datum.

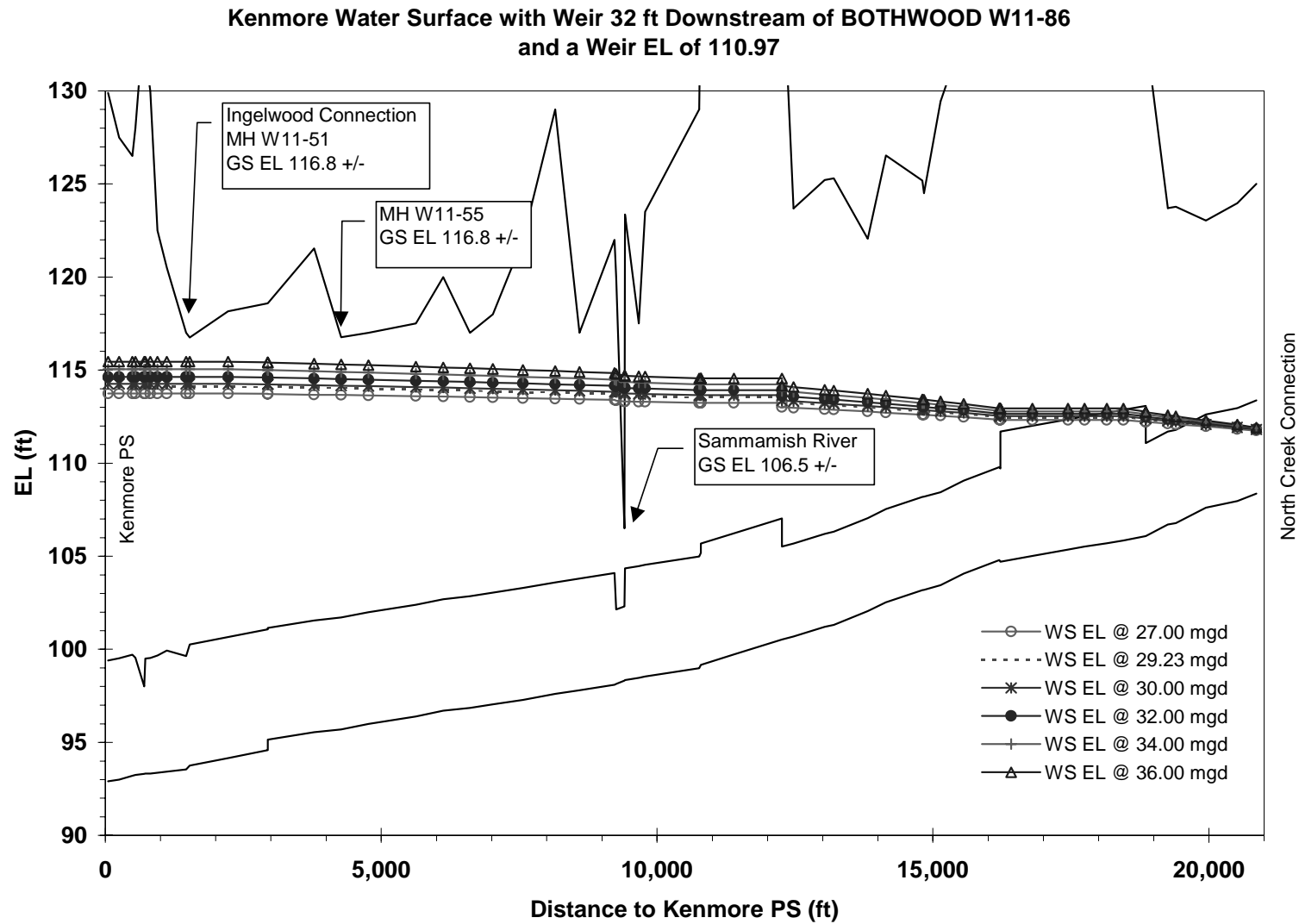
## Hydraulic Analysis

In May 1995, KCWTD staff prepared a memo that analyzed the feasibility of reversing the flow of wastewater in the Bothell-Woodinville Interceptor from the Kenmore Pump Station to MH W11-86, the North Creek Pump Station Diversion Structure. This memorandum, which is included in Appendix A, indicated that the interceptor should be able to be surcharged sufficiently to cause excess flow to back up the pipe and be drained into the North Creek Pump Station given a weir elevation of about two feet above the pipe invert at MH W11-86 or 110.97 feet ( $108.97+2=110.97$ ). The sources of wastewater to the Kenmore Interceptor identified in the 1995 report are summarized in Table 4. These flows were used as the basis for the hydraulic analyses presented in this report.

**Table 4. Sources of Wastewater to the Kenmore Interceptor**

Source	Flow (mgd)	Percentage of Total
MH W11-48	0.27	0.9
MH W11-51 (Inglewood Interceptor)	3.05	10.4
MH W11-53 (Swamp Creek Trunk)	16.60	56.8
MH W11-56	0.48	1.6
MH W11-59	0.80	2.7
MH W11-60	0.80	2.7
MH W11-62	0.32	1.1
MH W11-72A	0.35	1.2
MH W11-74	1.40	4.8
MH W11-78	2.43	8.3
MH W11-79	0.83	2.8
MH W11-85	1.90	6.5

The analysis in this memorandum builds upon this earlier work to analyze the hydraulic limitations of the Kenmore Interceptor/Bothell Woodinville Interceptor. This analysis validates the 1995 analysis. In addition, it indicates that surcharging peak flows of up to 32 mgd should not cause overflows into the Sammamish Slough from the Inglewood Interceptor (Figure 2; Table 5).



**Figure 2. Surcharged Kenmore Water Surface Elevations for Various Peak Flows.**

**Table 5. Critical Water Surface Elevations for Various Peak Flows**

Peak Flow (mgd)	WS EL at MH W11-51 (ft)	WS EL at MH W11-55 (ft)
27.0	113.7	113.7
29.2	114.1	114.0
30.0	114.3	114.2
32.0	114.6	114.5
34.0	115.0	114.9
36.0	115.5	115.3
Note: GS EL at both MH W11-51 and W11-55 (Inglewood Interceptor Connection) is 116.8 ft.		

The hydraulic analysis was conducted using the Chézy-Manning equation, with additional headloss factors for gradual and abrupt contractions and enlargements. The Chézy-Manning equation is:

$$h_L = \frac{V^2 n^2 L}{2.21 R^{4/3}}$$

where  $V$  is the water velocity,  $n$  is the Manning's number,  $L$  is the length of the pipe, and  $R$  is the hydraulic radius. The Manning's  $n$  was assumed to be 0.013 in the analysis. The Chézy-Manning formula provided the closest match to the results of the 1995 analysis for the same flow conditions while the Hazen-Williams headloss equation resulted in slightly more conservative, i.e. greater, headloss. Table 6 lists the water surface elevations at MH W11-51 for a peak flow of 29.23 mgd, the flow value previously used by KCWTD staff, from the different calculations. The details of these hydraulic calculations are provided in Appendix C.

**Table 6. Water Surface Elevations from Different Headloss Calculations.**

Analysis	WS EL (ft) at MH W11-51
1995 analysis	114.1
Chézy-Manning ( $n = 0.013$ )	114.1
Hazen-Williams (with $C = 100$ )	115.2
Hazen-Williams (with $C = 120$ )	114.2

From discussion with KCWTD staff, there have been no reported overflows during dry weather when the Kenmore Pump Station is bypassed and wastewater surcharges the local system up to approximately 112 +/- feet.

## Local System Analysis

Historical records were reviewed to determine the locations at the greatest risk for overflows if the Kenmore Interceptor were surcharged. This historical search was comprised of a review of KCWTD overflow data and claims records as well as review of local sewer system maps. The review showed that there has been only one report of a system overflow during dry weather conditions when the Kenmore and Bothell-Woodinville Interceptor have been surcharged to purposefully bypass flow around the Kenmore Pump Station. The overflow occurred at the Kenmore Pump Station on August 31, 2000 due to an operational error during a planned pump station shutdown. A total of 86,000 gallons of wastewater was released in seven minutes before the

situation was corrected. In addition, there have been three reported claims in the Kenmore area, all associated with the December 1996 storm. These three parcels, identified in Table 7, are located along NE 175<sup>th</sup> Street in Kenmore. Further information regarding the parcels affected by overflows is listed in Appendix B.

**Table 7. Kenmore Area Sewer Backup Damage Claims**

<b>Parcel</b>	<b>Date of Claim</b>	<b>Damage Claim</b>
7031 NE 175th	December 31, 1996	\$180
8311 NE 175th	December 31, 1996	\$35,498
8333 NE 175th	December 31, 1996	Not recorded

From a review of the Northshore Utility District (NUD) record drawings for the local side sewers in the vicinity of Bothell Way NE and NE 175<sup>th</sup> Street, it was determined that several side sewers with invert elevations less than 116 feet would be affected when the Kenmore Interceptor is surcharged. These pipes are those closest to the Kenmore Interceptor's MH W11-52 and W11-59, the area north of MH W11-56, and next to the Swamp Creek Trunk's W501-4. Figure 3 shows the invert elevations of the local sewers in the Kenmore area.

Figure 3 also highlights NUD and KCWTD manholes with rim elevations less than 2.0 feet above the maximum water surface elevation for a 36 mgd surcharge. These manholes are listed in Table 8 along with the modeled water surface elevation. No manholes have rim elevations below the modeled 36 mgd water surface elevations. The remainder of the local pipes reviewed generally have manholes with rim elevations greater than 120 feet.

**Table 8. Manholes with Rim Elevations within 2.0 feet of Max WS EL**

<b>MH</b>	<b>MH Invert EL</b>	<b>MH Rim EL</b>	<b>WS EL at 36 mgd surcharge</b>	<b>Freeboard at 36 mgd surcharge</b>	<b>Closest KCWTD MH</b>	<b>KCWTD MH Rim EL</b>
MH-526A	107.3	117.0	115.3	1.7	W11-56	117.0
MH-950	108.1	116.5	115.1	1.4	W11-59	117.8
MH-950A	108.0	116.5	115.1	1.4	W11-59	117.8
W11-51	93.8	116.8	115.5	1.3	n.a	n.a
W11-55	95.7	116.8	115.3	1.5	n.a	n.a
W11-56	96.0	117.0	115.3	1.7	n.a	n.a
W11-59	96.8	117.0	115.1	1.9	n.a	n.a

Many of the KCWTD manholes on the Kenmore Interceptor also have one or two 8-inch diameter risers, referred to on the record drawings as "piggyback" lines, that branch out from the manhole shaft along the path of the sewer main. Table 9 lists the risers that rim elevations at or below 116.0 feet. For MH W11-51, 115.5 feet is the modeled water surface elevation at this location for a 36.0 mgd surcharge. The water surface elevation at MH W11-52 is predicted to be 115.0 feet for a 34.0 mgd surcharge.

Place local map here

**Figure 3. Elevation of Local Sewer Pipes in Kenmore Area**

**Table 9. Risers with Rim Elevations 116.0 feet or Less**

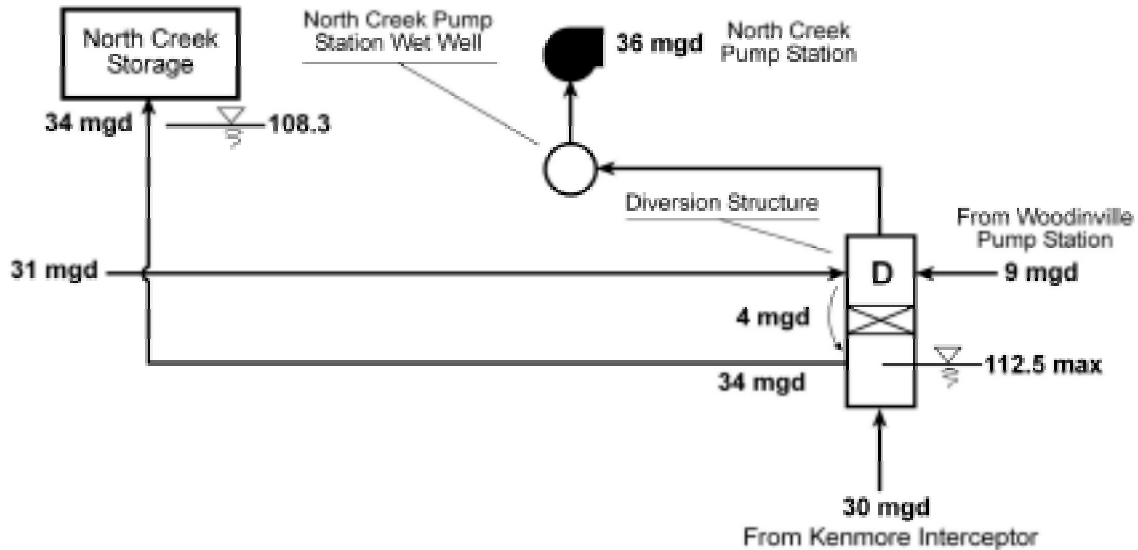
<b>Riser</b>	<b>Riser Invert EL</b>	<b>Riser Rim EL</b>	<b>KCWTD MH Rim EL</b>
Upstream W11-51	104.0	115.5	117.5
Downstream W11-52	103.0	115.0	116.0

Two of the three properties listed in Table 7 are adjacent to two of the selected NUD manholes, MH-950 and MH-950A, while the third property, 7031 NE 175<sup>th</sup> Street, is the location of the KCWTD risers. The focus of this analysis is surface flooding since, reportedly, the residences in the area of concern do not have basements because they are located in the Sammamish River floodplain.

From this review, it appears that surcharging the Kenmore Interceptor with up to 32 mgd peak flows should not cause wastewater to overflow onto the ground surface. At 34.0 – 36.0 mgd flows, wastewater will most likely overflow at the two KCWTD risers at 7031 NE 175<sup>th</sup> Street. Overflows from the NUD and KCWTD manholes are not expected for flows up to 36.0 mgd based on the hydraulic assumptions included in this analysis.

## **POTENTIAL OPERATIONAL SCENARIOS**

There were a number of potential operational scenarios for the North Creek Storage Facility discussed in the *North Creek Storage Facility October 2000 Predesign Report* by Tetra Tech/KCM, Affiliated Firms, and KCWTD. From the analysis presented in the predesign report and the hydraulic analysis in this memorandum, it appears that the most practical alternative is to divert wastewater from the Bothell-Woodinville Interceptor downstream of MH W11-86 as depicted in of the predesign report. Figure 4 below depicts this predesign report figure with the latest design modifications. It should be noted that the figure depicts a maximum water surface elevation in the storage structure of 108.3. It appears that this maximum water surface elevation is based on an undocumented level of free fall across the weir and the headloss from 30 mgd of wastewater flowing through the 54-inch diameter pipe to the diversion structure. The maximum water surface elevation in the storage structure could be as high as 114.5 feet if not higher under a different set of hydraulic conditions than those depicted in Figure 4.



**Figure 4. Diversion from Bothell-Woodinville Interceptor to North Creek Storage Facility**

Some potential operational scenarios were developed based on the available information. These operational scenarios are very preliminary and should be discussed and refined by KCWTD staff prior to the completion of the North Creek Storage Facility.

The following criteria were used to develop each operational scenario:

- Avoid overflows in Kenmore;
- Minimize diversion of wastewater to the storage facility; and
- Minimize the need for mechanical or electrical equipment to start the diversion of flow to the storage facility.

The basic winter and summer storage operations as currently envisioned until the North Treatment Plant comes on-line would include the following sequence of events:

1. Flow equals the capacity of the Kenmore Interceptor – Section 2 (the Kenmore Lake-Line)
2. Divert wastewater to Logboom Storage
3. Surge the Bothell-Woodinville Interceptor
4. Divert wastewater to the North Creek Pump Station
5. Divert wastewater to the North Creek Storage Facility

The refinements of this sequence of operation depending upon whether the North Creek Pump Station is operating or not prior to a storm event and other factors are described below.

### Winter Storm Event (Scenario 1)

The following more detailed potential operational scenario that was initially outlined by KCWTD staff is divided into storage and emptying modes for the North Creek Storage Facility.

### **Storage Mode**

1. Once the water surface elevation in the Kenmore Interceptor – Section 2 reaches a predefined set-point, wastewater will be diverted to the Logboom Storage Structures (4 MG storage).
2. Once that storage is full, Kenmore Pump Station will only pump enough to keep Logboom full (26 mgd minus flows from McAleer/Lyon and the basin connected to the Lakeline downstream of the Kenmore Pump Station).
3. Additional wastewater will back up the Kenmore Interceptor and Bothell-Woodinville Interceptor (2 MG of storage in the pipe).
4. The Bothell Gate at the diversion structure will normally be closed during the winter to divert wastewater from the North Creek Interceptor and Bothell-Woodinville Interceptor to the North Creek Pump Station.
5. When flows from the North Creek and Bothell-Woodinville Interceptors exceed the North Creek Pump Station's 36-mgd capacity, excess flow will spill over the weir at the Bothell Gate (EL 114.5 feet) and will be added to flow surcharging from the Kenmore Pump Station.
6. Once this flow gets up to the weir at the proposed diversion structure, it will flow to the North Creek Storage Facility.

### **Emptying Mode**

Once the flow of wastewater to the Kenmore Lakeline has subsided to less than the predefined water surface elevation, the upstream storage could be emptied in the following sequence:

1. Empty the wastewater stored in the Bothell-Woodinville Interceptor via the Kenmore Pump Station.
2. Empty the Logboom Storage Structures, making sure not to exceed the capacity of the Lakeline.
3. Empty the North Creek Storage Facility. The draft predesign report stipulates that the North Creek Storage Facility pump station will be designed with constant speed pumps to empty the storage facility in 24 hours, which equates to 6 mgd for a 6 MG facility. Wastewater would then be discharged to the North Creek Interceptor and the South Treatment Plant via the North Creek and York Pump Stations. The initial discharge rate from the pumps will be slightly higher than the average discharge rate since initially the differential head between the water surface in the North Creek Storage Facility and the North Creek Pump Station will only be a few feet.

### **Summer Storm Event (Scenario 2)**

In the summer, when the North Creek Pump Station is off-line at the start of the storm, the operational sequence will be similar to the winter operational scenario with a few important differences.

### **Storage Mode**

1. Same as winter.
2. Same as winter.
3. Same as winter.
4. The Bothell Gate at the diversion structure will normally be open during the summer to allow wastewater from the North Creek Interceptor and upper Bothell-Woodinville



Interceptor to flow to Kenmore. Existing monitoring equipment should be modified and new monitoring equipment should be provided to allow the North Creek Pump Station to come on-line and prevent unnecessary operation of the North Creek Storage Facility. Existing monitoring equipment that could be utilized includes level instruments in MH W85-1 and MH W11-87 as well as monitoring equipment for the Kenmore Pump Station and associated structures.

5. It reportedly takes 6-8 hours to start up the North Creek Pump Station. So, in some instances, it may be simpler to use the North Creek Storage Facility during the summer than to start up the North Creek Pump Station. Once the wastewater gets up to the weir at the diversion structure, it will flow to the North Creek Storage Facility. With a weir elevation set at 111.5 ft, up to 27.1 mgd can be conveyed down the Bothell-Woodinville Interceptor without having the water surface exceed the weir elevation, if there is no backwater from the Kenmore Pump Station.

### **Emptying Mode**

The sequence of steps involved in emptying the North Creek Storage Facility will most likely be similar to those involved in filling the facility. Once the flow of wastewater to the Kenmore Lakeline has subsided to less than 26 mgd, the upstream storage could be emptied in the following sequence:

1. Same as summer.
2. Same as summer
3. Empty the North Creek Storage Facility. In this case, wastewater would be conveyed to Kenmore by gravity rather than pumped to the South Treatment Plant.

As mentioned previously, these preliminary operational scenarios should be refined by KCWTD operations staff before construction of the North Creek Storage Facility is completed.

### **SUMMARY**

This report evaluated two facets of conveying wastewater in the Kenmore Interceptor: (1) surcharge conditions that would allow wastewater to backflow up the Kenmore Interceptor in an easterly direction from Kenmore to the proposed North Creek Storage Facility, and (2) normal operating conditions when wastewater flows down the Bothell-Woodinville and Kenmore Interceptors in a westerly direction from the North Creek area to Kenmore.

### **Backup (West to East) Operational Capacity and Overflow Locations**

The primary concern in the Kenmore area was to evaluate the potential for overflows when wastewater is conveyed west to east from the Kenmore Pump Station to the North Creek Pump Station, via the Kenmore Interceptor. The following conclusions can be made regarding Kenmore area overflows for west to east flows in the Kenmore Interceptor:

- No overflows are expected for easterly flows equal to or less than 32 mgd based on the assumptions identified in this report.
- Peak easterly flows greater than 32 mgd are expected to cause wastewater to daylight at the risers, or piggy-back lines, connected to MH W11-51 and MH W11-52. These two manholes are located near the plywood storage yard where previous overflows have occurred

during extreme storm events and appear to be the location where an overflow would occur first. These two piggy-back lines appear to have rim elevations of 115.0 and 115.5 based on available record drawings.

- KCWTD MHs and local agency MHs in the area all appear to have rim elevations of 116.0 or greater and are not expected to overflow for flows less than 36 mgd.

### **Normal (East to West) Operational Capacity and Overflows Locations**

For normal operations of the conveyance system, it was assumed that the desire of the KCWTD is to operate the North Creek Storage Facility only during large storms or when otherwise necessary to prevent an overflow from occurring. Therefore, it was assumed that maximum water surface in the Bothell-Woodinville Interceptor just downstream of the Bothell Gate would be 112.5 feet. It appears this water surface elevation is the basis for the design of the proposed North Creek Storage Facility Diversion Structure which has a weir elevation of 111.5 feet. Therefore, with a weir elevation of 111.5 feet, a maximum of 27.1 mgd can be conveyed down the Bothell-Woodinville Interceptor under normal flow conditions when the Kenmore Interceptor is not surcharged, without overtopping the weir in the North Creek Diversion Structure.

In summary, depending upon direction of flow, the capacities of the Bothell-Woodinville/Kenmore Interceptor are as follows:

1. Based on the assumptions in the report, 32 mgd can be conveyed in an easterly direction up the Kenmore and Bothell Woodinville Interceptors and into the North Creek Storage Facility, as it is currently proposed, without causing a MH to overflow in the Kenmore Area.
2. When the Kenmore Interceptor is not surcharged, it should be possible to convey 27 mgd in a westerly direction down the Bothell-Woodinville and Kenmore Interceptors without overflowing the weir in the North Creek Storage Facility Diversion Structure and necessitating operation of the North Creek Storage Facility.

**APPENDIX A**  
**PREVIOUS MEMORANDUM**

## **APPENDIX B**

### **PARCEL DATA**

# **APPENDIX C**

## **HYDRAULIC CALCULATIONS**